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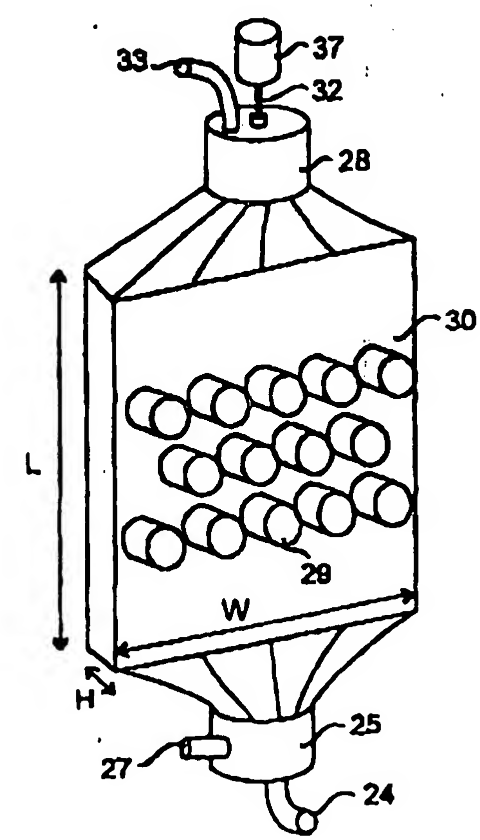
(54) Title: A MIXING METHOD AND A MIXING CHAMBER

(57) Abstract

A mixing chamber for mixing components added to a liquid, wherein at least one of the components has a tendency to flocculate or create agglomerations. The mixing chamber is provided with at least one inlet port (24, 27) for introducing the liquid and the components to be mixed and at least one outlet port (33) for discharging the mixed dispersion. Agitators in the mixing chamber can be rotated by a motor (37). The mixing chamber comprising at least one ultrasonic transducer (29) disposed to introduce ultrasonic energy into the liquid.



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TITLE

A MIXING METHOD AND A MIXING CHAMBER

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a method and a device for mixing additives into a liquid, and more specifically to a method and a device for continuously mixing additives into a liquid containing at least one constituent that has a tendency to flocculate or form agglomerations.

BACKGROUND OF THE INVENTION

Mixing two or more constituents into a liquid and arrive at a good homogeneous mixture, during continuous production conditions, is an essential task within many fields of industry.

However, depending on the characteristics of the constituents as well as of the liquid an optimal mixing is in many cases difficult to achieve. For example, such a difficulty is encountered when at least one of the constituents has a tendency to flocculate or form agglomerations.

This is a situation that is common in a number of industrial fields, such as the ink and paint manufacturing industry, the printing industry, the paper making industry and the chemical industry. The difficulty to achieve a good mixing is generally similar in these industries in that the various constituents, such as pigments, polymers and fibers, are forming agglomerations which significantly reduce the effectiveness of each constituent.

The paper making industry, wherein the problems mentioned above are very pronounced, shall here be used as an illustrative example.

In paper making, the main constituent to be mixed with water is the fibers from which the paper is manufactured. Various types of additives, such as dyes and chemicals, are added in order to produce a paper with desired properties.

In a stock flow with a consistency of 1-5 % fibers, the fibers are present in a flocculated state, which means that a number of separate fibers are attached to each other. The flocks flow with the liquid, but the liquid inside each flock is substantially entrapped within the flock and is stagnant in relation to the flock. Thus, various types of additives which are added to the stock are prevented to get in contact with the individual fibers inside the flock and, in fact, also with the inwardly directed surfaces of those fibers that are partly or entirely on the outside of the flock.

Conventional methods to reach a high rate of mixing when adding flocculating components to a liquid includes at least one of the following elements:

- reducing the concentration of the flocculating component by adding more liquid;
- providing a long dwell time during the mixing;
- repeated re-circulation through the mixing chamber; and
- heavy stirring.

However, these elements have drawbacks that consequently confer disadvantages to a method in which they are used.

For example, reducing the concentration of the flocculating component means that more mass of liquid has to be transported for a given volume of flocculating components, resulting in raised energy and transportation liquid consumption. Furthermore, as large volumes of liquid are used large vessels for containing the liquid is, in consequence, necessary. Thus, the cost and time for change of color and grade is considerable. The volume of stock that will have to be wasted is large, and a lot of pump energy is required.

A long dwell time results in longer dead times in feed-back process controls.

Repeated re-circulation gives higher energy costs. This is also the case for the heavy stirring, especially when the stirring is utilized not only to mix the additives into the paper stock but also to disintegrate the flocks and keep them

disintegrated during the time needed to mix them with the additives. This also results in longer dead times.

Although the paper industry has been used as an example above, a similar situation is present also in other fields of industry as mentioned above.

SUMMARY OF THE INVENTION

It is the object of the present invention to provide an improved method and a device for continuously mixing components in a liquid where at least one component has a tendency to flocculate or form agglomerations.

This object is achieved, according to a first aspect of the invention, with a method as defined in claim 1.

According to a second aspect of the invention there is provided a mixing chamber, as defined in claim 5, for use with the method of the invention.

According to a third aspect of the invention there is provided a paper machine utilizing a mixing device according to the invention, as defined in claim 9.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be explained by reference to the accompanying drawings, wherein:

Figure 1 is a schematic diagram of the main components in a conventional flow system used for mixing additives to a paper stock in a paper machine.

Figure 2 is a perspective view of a mixing chamber according to the invention.

Figure 3 is a schematic cross-sectional side view of a mixing chamber according to the invention, such as the mixing chamber in fig. 2.

Figure 4 is a schematic cross-sectional front view of the mixing chamber in fig. 3.

Figure 5 is a schematic diagram of the main components in a flow system according to the present invention used for mixing additives to a paper stock in a paper machine.

Figure 6 is a schematic diagram of the main components in a flow system that is simplified as compared to the flow system in fig. 5.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

First, a conventional method for mixing components, wherein at least one component has the tendency to create flocks or agglomerations, into a liquid shall be described in more detail. This is made with the use of an example taken from the paper industry.

According to the schematic of fig. 1, a flow system for mixing components into water in a paper machine includes a paper stock conduit 2 conveying paper stock from a pulp plant or a pulp dissolver via a stock preparation department, a mixing chest 3, a first agitator 5 in the mixing chest, a machine chest 6, a second agitator 8 in the machine chest, a circulation conduit 9 with a first pump 18, an overflow 10, a second conduit 11 with a second pump 19, a level box 12, an overflow conduit 14 and an outlet conduit 15 to the paper machine (not shown).

The stock, i.e. cellulose fibers mixed in water, is added to the mixing chest 3 through the paper stock conduit 2 together with additives 1, such as dyes and fillers. The addition of additives is usually made continuously by adding a slurry containing the additives, but is sometimes made batch-wise. The mixing is enhanced with the first agitator 5.

The mixing chest 3 is used not only for mixing additives into the stock, but also as a means for controlling the fiber concentration of the stock in those cases where the concentration of stock being added from the paper stock conduit 2 is not of sufficient accuracy.

From the mixing chest 3 the stock, including additives, is pumped via the circulation pump 18 to the machine chest 6. The stock is kept in motion in the machine chest by the second agitator 8. A substantial part of the mixture is re-circulated to the mixing chest 3 via an overflow 10 in order to provide a long dwell time. A small part of the stock and additive mix is pumped by the second pump 19 to the level box 12 which has a stock overflow 13 which flows back through the overflow conduit 14 to the mixing chest 3.

A part of the stock and additive mixture 11 is forwarded through the outlet conduit 15 to the short circulation system (not shown) of the paper machine to be used for the paper making.

As has been previously stated, paper quality change is time consuming and, consequently, costly with the conventional method since such a large volume of stock and additives has to be discharged before the fibers and additives necessary for the next paper quality can reach their proper concentrations.

This time delay can be highly reduced by the method of the invention for mixing components added to a liquid, wherein at least one component has a tendency to flocculate or create agglomerations, said method including the steps of:

conveying the liquid with the components through a mixing chamber, said mixing chamber being provided with at least one agitator and at least one ultrasonic transducer;

introducing ultrasonic energy into the liquid as it passes through said mixing chamber; and

stirring the liquid with the agitator as it passes through said mixing chamber.

The ultrasonic energy added to the stock blend within the mixing chamber creates cavitation bubbles in the stock blend which, when imploding, create chock waves. By a proper selection of ultrasonic frequency a wave length suitable for dispersion of fiber flocks and particle agglomerations can be reached. For example, the wave length of ultrasound having a frequency of 25 kHz in water is about 60 mm, making it suitable for said purpose.

When dispersed, the fibers are completely exposed for interaction with additives, and dispersion of particle agglomerations raises the efficiency of the additives. Therefore, since the fiber flocks are dispersed the additives can be readily mixed with the fibers and at the same time the additives are more effective in contacting the fibers.

Thus, according to the method of the invention, the need for re-circulation of the solution is considerably reduced and may in fact be completely omitted since the dispersion provided by the ultrasonic energy makes the mixing so effective that the mixed solution can be directly transferred to the subsequent steps of the overall process of which the mixing forms a part.

An embodiment of a mixing chamber for use with the invention shall now be described with reference to fig. 2, 3 and 4. The mixing chamber includes a first inlet port 24, a second inlet port 27, an inlet chamber section 25, a first agitator paddle 26, an intermediate chamber section 30, ultrasonic energy sources 29, a second agitator paddle 31, a stirrer spindle 32, an outlet chamber section 28 and an outlet port 33.

Water, optionally with at least one component such as fibers, is conveyed into the inlet chamber section 25 through the first inlet port 24 by the action of at least one pump (not shown). Further additives are added through the second inlet port 27. A premixing is achieved by the stirring action of the rotating first agitator paddle 26. The stirrer spindle 32, that is common for both the first agitator paddle 26 and the second agitator paddle 31, is being rotated by a motor 37 outside the chamber.

It should be noted that the agitator paddles, of course, may as well have separate spindles and driving motors, if this is preferred. In fact, the agitating action could be achieved also with other agitating means, such as flow guides or water jets.

The liquid is conveyed from the inlet chamber section 25 into the intermediate chamber section 30. The intermediate chamber section has two parallel sides 34, 35, each having a length L in the direction of the stock flow and a width W transverse to the flow direction. At one side 35 the intermediate chamber section 30 is provided with ultrasonic energy sources 29, preferably consisting of conventional electromechanical ultrasonic transducers and preferably all of the same size and power, secured to the outside of the chamber section by e.g. bolts or welding. For high dispersing efficiency, the distance between a transducer and its next neighbor is so adapted that a substantially continuous ultrasonic field will be present in the solution beneath the transducers. Typically, this means that the distance between two transducers outer edges is not more than the diameter of the transmitting surface of one of the transducers, i.e. the center to center distance between two adjacent transducers should not exceed double the diameter of the transmitting surface of one transducer.

The height H of the flow path in the intermediate chamber section 30, i.e. the distance between its parallel sides 34, 35, is adapted to provide a substantially continuous ultrasonic field in the liquid between the parallel sides during operation of the ultrasonic transducers 29. For maximum dispersing efficiency, the height H between the parallel sides in a case of transducers on one side only, as in the embodiment shown in fig. 2 through 3, should be a multiple of one half wavelength but not exceed two wavelengths. Similarly, in an embodiment wherein both the parallel sides are provided with transducers the height H between the parallel sides should be an odd number of half wavelengths, though not exceeding seven half wavelengths. Preferably, the wavelengths of the transducers are tuned to correspond to the height H chosen.

It should be noted that in order to achieve best possible ultrasonic energy transmission from the transducers to the stock flow, it is preferred to stiffen the chamber side wall on which the transducers are mounted, for example with stiffening beams (not shown in the figures), so that the transducers can be controlled to vibrate the wall uniformly.

When the liquid passes between the ultrasonic energy emitting transducers, fiber flocks and particle agglomerations are dispersed as described above.

After passing through the intermediate chamber section 30, the solution is conveyed through the outlet chamber section 31, wherein the rotation of the second agitator paddle 28 ensures good mixing of the still dispersed components in the solution. Finally, the mixed solution is discharged through the outlet port 33.

The preferred embodiment of a mixing chamber as described above is operable on a continuous basis. That is also the case for other embodiments falling within the inventive concept of the present invention. Such embodiments may, for example, include a tubular intermediate chamber having ultrasonic transducers disposed around its outer barrel surface as well as on its butt ends.

The ultrasonic energy sources 29 are preferably conventional electromechanical ultrasonic transducers, although other ultrasonic energy generating means, such as steam pulse injecting devices, could be used as well.

The introduction of a mixing chamber, for use with the method of the invention, in a flow system of a paper making machine similar to the conventional flow system illustrated in fig. 1 is shown in fig. 5. Those components of the flow system in fig. 5 that are similar to the corresponding components of the conventional flow system according to fig. 1 are designated with the same reference numerals, and the description of these components shall not be repeated herein.

Referring to fig. 5 a mixing device 20 according to the present invention is disposed in conduit between the second pump 19 and the level box 12. Thus, taking the mixing device embodiment as shown in fig. 2 as an illustrative example, the first inlet port 24 is connected to the second pump 19 via a first part of the conduit 11' and the mixing device outlet port 33 is connected to the level box 12 via a second part of the conduit 11".

Additives are added to the second inlet port 27 of the mixing device 20 via an additive conduit 1'.

In operation of the flow system according to fig. 5, the stock, having a well defined concentration, is conveyed from the machine chest 6 via conduit 11' through the mixing device 20. Additives are added to the stock through the conduit 1' on a continuous basis and at the same time the ultrasonic transducers 29 are active to disperse the fiber flocks of the stock and agglomerations of additives. The mixed stock solution is conveyed through conduit 11" to the level box 12 and from there into the outlet conduit to the short circulation system (not shown) of the paper machine to be used for the paper making.

It is easily understood that the internal volume of the flow system that has to be washed clean during a paper quality change, provided that the same stock quality is used, is considerably less in a flow system according to fig. 5 as compared to the conventional system in fig. 1.

Furthermore, in a case where the concentration of the stock delivered through the paper stock conduit 2 is of sufficient precision and stability the mixing chest 3 may be omitted entirely.

Fig. 6 shows such a simplified flow system, wherein same components as in fig. 5 are designated with the same reference numerals. As compared with the flow system in fig. 5, the mixing chest 3, and the components attached to it, have been omitted so that stock from the paper stock conduit 2 and the overflow

conduit 14, respectively, is added directly to the machine chest 6'. Thus, investment costs can be reduced.

Experiment

An experiment was performed to verify the technical effect of the present invention with regard to dyeing efficiency.

An intermediate chamber section similar to the embodiment shown in figures 2 through 4, having a length L of 20 1/2 inches (520 mm), a width W of 18 1/8 inches (460 mm) and a height H of 1 1/8 inch (35 mm) was used. Fourteen electromechanical transducers, each with a nominal power rating of 300 W, where attached to one side of the chamber in a 5 + 4 + 5-arrangement (as seen in fig. 2). The transmitting surface diameter of each transducer was 3 1/16 inches (78 mm), and the maximum center to center distance between each adjacent transducer was 6 5/16 inches (160 mm). The transducers were driven at a frequency of 18.6 kHz.

Paper stock with a fiber content of 1.5 % was conveyed through a pilot paper machine at a flow rate of 2.8 cubic feet/min (80 dm^3/min).

In a first part of the experiment additives where added using conventional mixing in a mixing chest.

The additives consisted of dye and retention agents. Thus, CIBA Unisperse Violet B-E pigment color was added as a water solution (1:20.83) at a flow rate of 11 cubic inches/min (180 ml/min), representing a dye versus fiber weight ratio of 1 %. CDM Pericol 1243 retention agent was added as a water solution (1:800) at a flow rate of 6.1 cubic inches/min (100 ml/min) solution.

Hue measurements utilizing the CIELAB color measuring units gave the following results for the conventional method of mixing:

$L^*=79.04$ $a^*=7.44$ $b^*=-11.4$

In a second part of the experiment the mixing chamber as defined above was installed in the pilot paper machine at a position as indicated at 20 in fig. 5. The same additives as defined above, in like concentrations and flow rates, were added. The retention aid was added before the fan pump, as in the first part of the experiment, and the dye was added at the mixing chamber inlet and was mixed to the stock flow using the method of the present invention.

Hue measurements utilizing the CIELAB color measuring units gave the following results for the method of mixing according to the invention:

- $L^*=76.45$ $a^*=9.54$ $b^*=-14.8$

As becomes clear for anyone familiar with the CIELAB color measurement system, the dyeing was made with higher efficiency when using the mixing chamber according to the invention as compared to the conventional mixing chest mixing. Therefore, the experiment showed that using the method of the invention the same paper color can be obtained using less dye, as compared to the conventional mixing procedure.

CLAIMS

1. A method for mixing components added to a liquid, wherein at least one component has a tendency to flocculate or create agglomerations, said method including the steps of:

    conveying the liquid with the components through a mixing chamber, said mixing chamber being provided with at least one agitator and at least one ultrasonic transducer;

    introducing ultrasonic energy into the liquid as it passes through said mixing chamber; and

    stirring the liquid with the agitator as it passes through said mixing chamber.

2. The method according to claim 1, wherein the liquid is water and one of the components is paper fibers.

3. The method according to claim 1, wherein said at least one ultrasonic transducer is an electromechanical ultrasonic transducer.

4. The method according to claim 1, wherein said at least one ultrasonic transducer is a steam pulse injecting ultrasonic energy generator.

5. A mixing chamber for mixing components added to a liquid, wherein at least one of the components has a tendency to flocculate or create agglomerations, said chamber being provided with at least one agitator and comprising at least one ultrasonic transducer disposed to introduce ultrasonic energy into the liquid.

6. The mixing chamber according to claim 5, wherein said at least one ultrasonic transducer is an electromechanical ultrasonic transducer.

7. The mixing chamber according to claim 5, wherein said at least one ultrasonic transducer is a steam pulse injecting ultrasonic energy generator.

8. The mixing chamber according to claim 5, wherein the at least one ultrasonic transducer is mounted on at least one of two parallel side walls of said mixing chamber.

9. A paper machine in which paper stock and additives in the paper stock are conveyed through a conduit to a level box, said paper machine comprising a mixing chamber and said mixing chamber being provided with at least one agitator means to mix the paper stock and the additives, and comprising at least one ultrasonic transducer disposed to introduce ultrasonic energy into the paper stock, and said mixing chamber being disposed in the conduit conveying the paper stock to the level box.

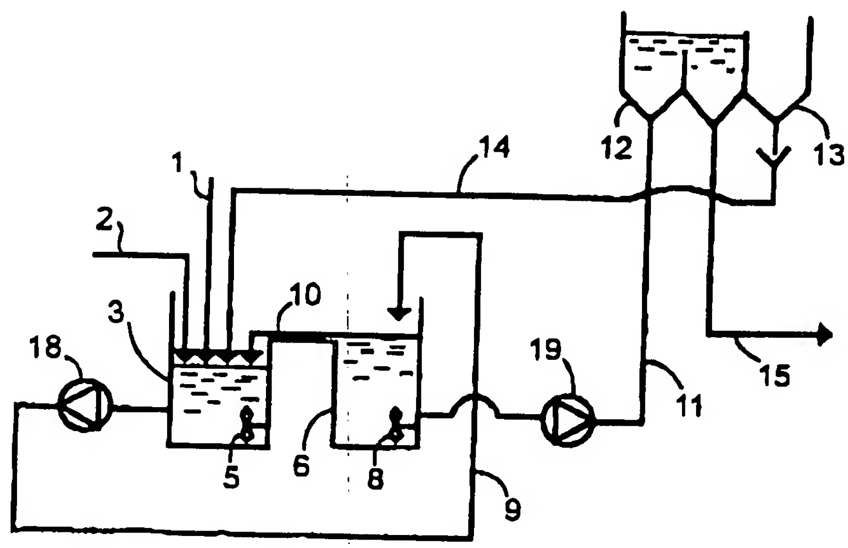

Fig. 1

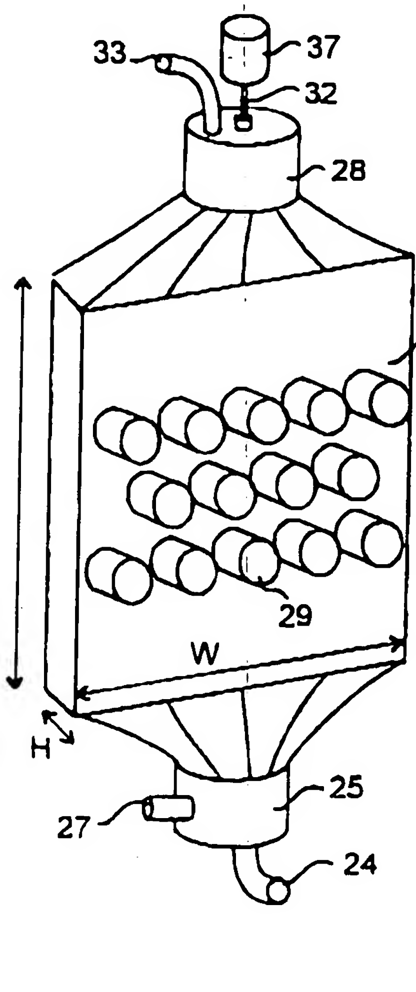

Fig. 2

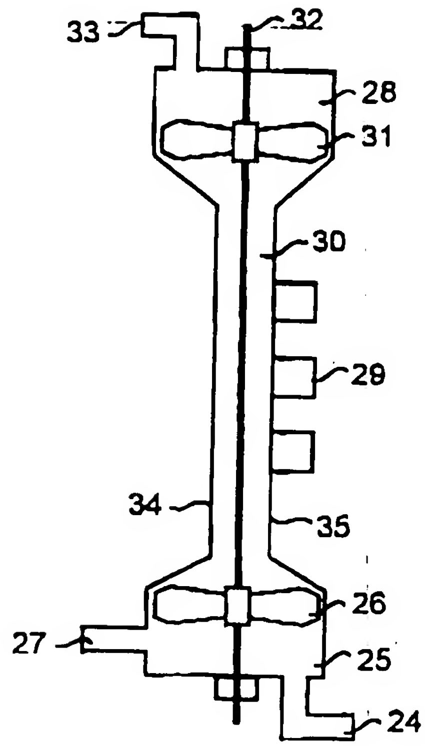

Fig. 3

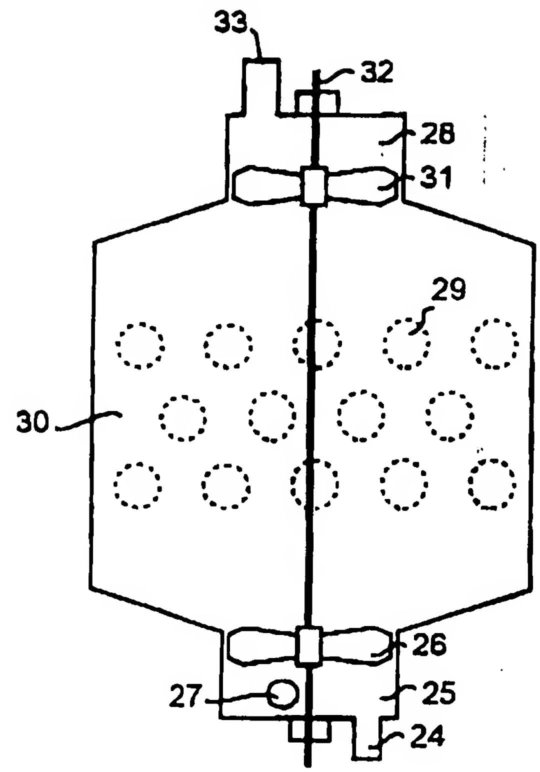

Fig. 4

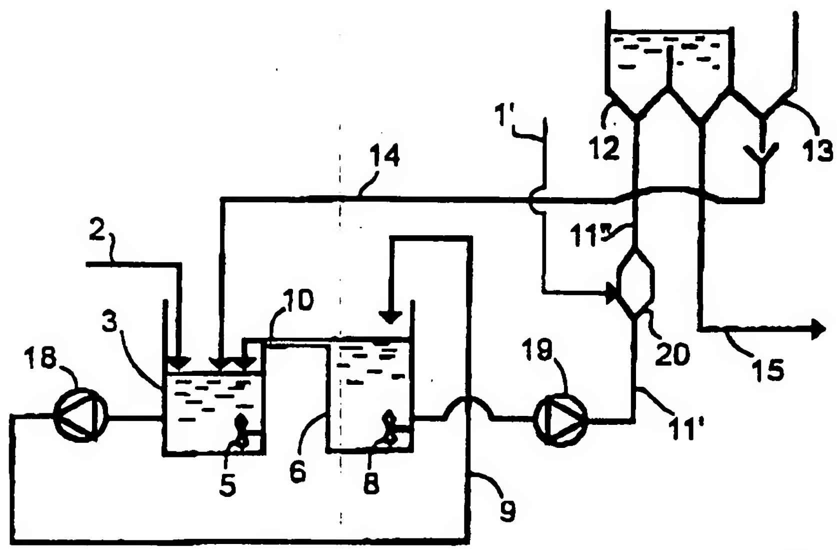

Fig. 5

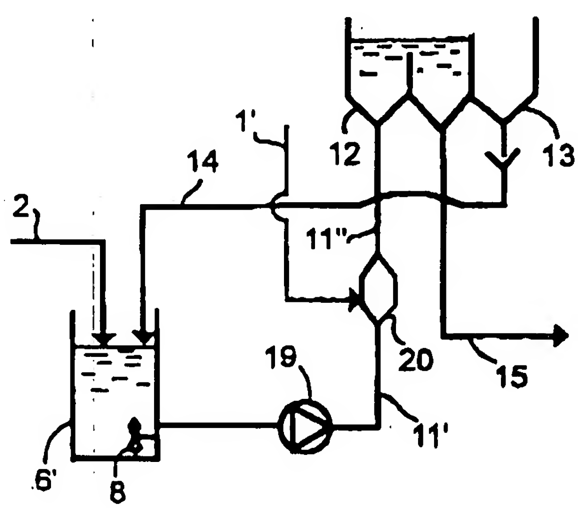

Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 99/01585

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B01F 11/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

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Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI, EPODOC, PAJ, US FULLTEXT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4302112 A (PER R. STEENSTRUP), 24 November 1981 (24.11.81), column 3, line 25 - line 50, figure 1, claim 1	1,5
A		2-4,6-9
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INTERNATIONAL SEARCH REPORT
Information on patent family members

02/12/99

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4302112 A	24/11/81	CH 644278 A	31/07/84
		DE 2933176 T	04/12/80
		DK 24578 A	19/07/79
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